Information Technology in the Health Care Industry

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The health care information systems market has grown to a multi-billion dollar industry, with a predicted average annual growth rate of 12% through the year 2000. This paper provides an overview of information and management technology applications in health care for (a) medical diagnosis and treatment; (b) health care administrative functions; and (c) special applications of information technology to health care problems.

Introduction

In 1968, American hospitals employed 435,100 administrators while caring for 1,378,000 patients on a daily basis. By 1990, the average daily number of patients fell to 853,000 while the number of administrative personnel rose to 1,221,600. In 1990, health expenditures were $666.2 billion: $256 billion on hospital care with $63 billion of those funds going toward administrative expenses.[1] The magnitude of these cost figures and the obvious ballooning of the administrative portion of health care costs point clearly to the need for improved information technologies to manage the system.

Commensurate with the growth of health care costs, the health care information systems market has also grown to between an $11 billion and $23 billion industry in 1996, depending on which items are included, with a predicted average annual growth rate of 12% through the year 2000.[2] Trends indicate that healthcare systems are shifting their information technology investments away from cost-management tools and toward technology facilitating the integration of delivery systems and preparation of managed care.[3] In addition, expenditures on technology to improve clinical outcomes are expected to more than double in the next three to five years, reaching 18% of the total technology budget.

These huge investments in technology are expected to reap heavy benefits. One expert estimates that the potential overall healthcare saving that can be achieved by using information technology is $159 billion.[4] These benefits derive from efficiencies in the way information is used to measure, record, retrieve, diagnose and communicate in the process of patient care and administration.

Many of the advances in health care technology are not arising out of the medical marketplace, but are being driven by either the business world or the entertainment industry. For example, the medical imaging technologies used in computed tomography are based on computer modeling techniques developed in the film industry, which enable people to do three-dimensional reconstructions more rapidly and achieve higher resolution from imaging modalities.[5] Faster and more powerful computers developed for business and engineering applications are also being applied to medicine to allow the management and integration of a myriad of patient record information for higher quality treatment, and more efficient and cost effective health care management.

The purpose of this paper is to provide an overview of information and management technology applications in health care. It is organized into three major sections, which, due to the nature of modern health care management systems, have become highly integrated in practice: (a) the use of information and computer technology in medical diagnosis and treatment; (b) the use of information technology in health care administrative functions; and (c) special applications of information technology to health care problems.

Information and computer technology in medical diagnosis and treatment

Diagnostic and treatment technologies

New technologies for the diagnosis and treatment of disease have dramatically changed the health care industry over the past decade. Diagnostic radiology has become a critical element in patient management and patient care, because early and accurate diagnosis of disease is an essential component of effective therapy. For example, diagnostic tools such as X-ray computed tomography, ultra-sonography, positron emission tomography (PET), single photon emission computed tomography (SPECT), and Magnetic Resonance Imaging (MRI) use advanced techniques with computer-assisted programs to evaluate and shape data to help in clinical decision making. The imaging techniques used in these applications are continuously being improved, resulting in better data acquisition, especially for dynamic MRI[6], and allowing them to replace more invasive procedures. Such diagnostic techniques can provide more and better information at lower risk, and similar or lower cost.[7] As the demand for computer-assisted diagnostic procedures grows, and the technology is applied to a wider variety of medical diagnostic settings, the imaging technology applied will also no doubt improve, and the need for faster, cheaper and more sophisticated computer hardware and software to generate these images will

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follow. The use of imaging in health care has prompted several key trends in the field.[8] These include:

* *Digital Image Communications*, which allows the transfer of image data and associated patient and study data in a form understood by anyone.
* *Teleradiology overread services*, through which many radiology groups are increasing their referral base of smaller hospitals by contracting services during evening and weekend hours for overread.
* *Teleradiology on a local basis*, which allows radiologists to render opinions from their homes.
* *Integrated Information and Picture Archival Communication Systems*, which transmit images from radiology to the Intensive Care Unit, Critical Care Unit or Emergency Department for viewing.

Computer technology has also been developed to help doctors predict and visualize the outcome of certain types of treatment. For example, in cosmetic and reconstructive surgery and dentistry, the use of computer modeling helps patients and doctors envision the outcome of certain treatments to assist in making better decisions about treatment options. And computer systems are incorporated into many advanced medical treatments, such as surgeries involving laser technology, the administration of drugs, and various other applications.

Clinical Information Systems

The increased use of digitized medical imaging in diagnosis and treatment, along with the need to achieve economies of scale throughout healthcare networks, has prompted the development of Clinical Information Systems (CIS) or Computer-Based Patient Records (CPR), which allow physicians, nurses, dietitians, social workers, physical therapists and a range of other care-team members to share information about patients directly through the system.[9] Sophisticated CPR systems may require a wide variety of advanced user-to-computer interfaces, including speech recognition, text-to-voice and voice-to-text conversion, barcode scanning, direct digital equipment and application-program interfacing. Other features could include CD-based video recording and playback, microwave broadcast and graphical user interfaces employing voice, pen, mouse and keyboard controls. Such CPR systems can improve patient care through the integration of a rules-based set of care plans that the clinical team can use to establish and sustain a complete set of protocols for diseases, medical problem sets and medical procedures.

For example, ProMedica implemented a CIS system called the 3M Master Member Index, loading some 750,000 patient records into the system which will allow ProMedica to manage multiple methods of identifying patients at multiple locations, accept and display clinical results from a variety of existing systems, and provide clinicians with decision support through system-generated clinical alerts.[10] The system not only includes the standard demographic data and insurance/billing information, it also allows streamlined access to detailed patient data including physician notes and data from current and previous physician encounters, laboratory and pathology results, and pharmacy records. A strategic advantage of the system is the clinical alerting software which uses expert system technology to analyze and correlate patient data entering the clinical data repository, and generates "alerts" as indicated or specified in advance by the users. In a similar fully-integrated CIS, Graduate Health Systems developed a system which includes not only admissions, discharges and transfers within the hospital, but also nearly 75 percent of the final patient record, including physician orders for ancillary services (laboratory tests, radiology procedures, etc.) and all results from patient tests and procedures.[11]

Computerized medical records systems typically have five levels of implementation.[12] The majority of providers are at the first level, while a few hundred providers are at the level of creating computerized medical records with document imaging. The five levels of implementation are:

Level 1: Automated medical records, which still depend on paper-based medical records, even though as much as 50% of patient information is computer-generated and stored in the form of computer printouts within the medical record.

Level 2: Computerized medical record systems in which traditionally generated medical records are indexed and scanned into a system using document imaging.

Level 3: Electronic medical records, which is an upgrade from level 2, and requires a common format and accessing techniques throughout the enterprise.

Level 4: Electronic patient record systems which focus on the patient and contain information from one or more provider enterprises.

Level 5: The electronic health record, a more comprehensive system which includes a network of provider and non-provider settings based on the patient as being the center.

There are a number of software companies that provide information systems designed to assist physicians, nurses and other clinicians in making decisions about patient diagnosis and treatment.[13] These systems range in price from several hundred to several thousand dollars, and similarly incorporate a wide range of features including diagnostic decision and support systems, and a range of input and output devices.

Clinical information systems are a good example of electronic document management (EDM) in health care, since they incorporate information from many different types of sources, including number, text, sound, digitized images, object-oriented images, computer-aided drawings, voice, video, animation, holographic images, even magnetic photographs that can be digitized immediately and shown on a television or sent over a phone line.[14] Since CIS systems are used heavily in treatment decisions, they must be designed to be run by personnel familiar with the needs and constraints of the medical professional using them. The information systems department will need to provide the infrastructure sufficient to operate these systems, including 1) network links with enough capacity to carry images, 2) workstations capable of displaying high-resolution graphics, 3) storage devices that can handle the huge image and voice files, and 4) standards for each of the various forms of data.[14,15] Once implemented, CIS systems can offer high payoffs by increasing operating efficiency, improving organizational effectiveness, and as a competitive weapon to link various medical providers within a larger system and more efficiently utilizing the expertise of specialists.

The CIS design team should include expertise from systems and records management, as well as medical professionals to provide operational expertise. Even if the CIS software shell is acquired rather than developed, healthcare companies may incur a significant

cost for converting and indexing the paper records so that there is a good retrieval system to make their use efficient and effective. Because of the confidentiality of medical records, system security is an issue, and because of the importance of correct medical decisions based on the system, data integrity is critical. Also, since a patient's medical records may be needed for years in the future, an important element in developing a CIS is specifying the electronic records management policy and system guidelines for accessing, saving and destroying various kinds of documents in the system.

Case Management Systems

Case-management systems are designed to identify and assist in the management and treatment of potentially high-cost, resource intensive cases. Generally, case-management tools are integrated with utilization and/or authorization management system protocols.[17] Chronic and acute case management profiles are offered and specific treatment plans or practices guidelines may be integrated into the case-management software. One trend in case management is the shift in focus to process care support through referral and case management, rather than precertification and length of stay assignment or authorization of specific inpatient care episodes.

As with CIS, several software companies offer Case-management systems, but these systems tend to be more expensive, ranging from a few thousand to tens of thousands of dollars. Features include outcomes management, quality and appropriateness of care, comparisons of actual practice patterns to critical path, and evaluation of patient-level detail against internal and external standards.[18,19]

Applications of information technology in health care administrative functions

Health information networks

Health information networks describe the array of healthcare information networks which generally follow four major strategies.[20]

Tactically focused health information network initiatives - are created to support one or several focused business initiatives, such as improving in-house lab volume or linking competing hospitals to share data for transferred patients. For example, a hospital interested in increasing the utilization of its in-house clinical lab will install network links to community physicians and offer a user interface that supports the entry of lab orders and retrieval of results.

Administratively focused networks - are designed to support administrative and financial processes, such as the routing of patient registration, eligibility, benefit, claims and encounter transactions. These systems provide administrative simplification and operational efficiencies and focus on reducing staff telephone and turnaround time for high-volume administrative patient/member processes.

Clinically focused networks (networked CIS) - are developed to support the movement of clinical transactions.

Universal networks - are conceived to support a wide range of enterprise transactions and communication methods, as well as the routing of administrative, financial and clinical transactions. They are designed to support both clinical and management enterprise wide objectives.

Community Health Information Networks (CHIN) and Regional Health Information Networks (RHIN), are an integrated collection of computer and telecommunications capabilities that facilitates communication of patient, clinical and financial information among multiple providers, payers, employers, pharmacies and related healthcare entities within a targeted geographic area.[21] Forces driving the formation of CHINs include President Clinton's healthcare initiatives, and also market pressures for cost reduction, federal regulations, vendor initiatives and outcome measurements. CHINs can be either non-profit entities operated by institutions, foundations or geographic consortiums, or for-profit entities with a vendor-owned and operated data base. The benefits of CHINs accrue to patients, providers and employers in the form of reduced paperwork, improved quality of care, and ability to compare provider cost and performance. Examples of CHINs include Ameritech Health Connections, Inc., Henry Ford Health Alliance Plan, and PRAXIS.

Issues critical to the effective implementation of CHINs include electronic data interchange standards which can be applied to electronic transactions for claims, claims attachments, enrollment and disenrollment, eligibility, healthcare payment and remittance advice, premium payments, first report of injury, and claims status.[22] Another problem that must be addressed before CHINs will achieve their full potential is the development of efficient and effective Master Patient Indexes (MPIs). These systems allow the accurate identification of the patient and cross reference of patient identifiers for each location in the enterprise.[23] MPIs are essential to data security and integrity.

Special Applications of Information Technology to Health Care

Artificial intelligence - Artificial intelligence provides the opportunity to capture and combine the professional judgment and expertise of experts for the use of less qualified personnel. For example, Med-Al Inc., Orlando won the 1994 Healthcare Innovations in Technology Award for the company's product to detect myocardial infarction (MI) in patients. The MI Predictor used artificial intelligence to recognize the variables and combination of variables that determine if a patient is having a heart attack. The MI predictor is 97% accurate, according to Med-Al sources.[24]

Decision support systems and Management support systems- Experts estimate that the U.S. healthcare decision-support market is valued at more than $100 million and is growing faster than the market for all healthcare software.[25] Decision support systems (DSS) could be extremely useful in the integrated delivery network or enterprise model. DSS can integrate information from databases that capture and store clinical and administrative data, and model relationships among variables. Furthermore, a well-designed DSS can enable professionals to communicate more efficiently.

Simulation applications - Applications of computer simulation to health care include modeling the outcome of several alternative pathways of treatment to find the most efficient and effective way of processing patients. For example, Central Baptist Hospital in Lexington, KY used simulation software to find options that decreased the average length of stay for patients in the hospital's emergency department.[26] The simulation helped identify patient-flow barriers in the emergency department, reduce overall patient turn-around time, and reduce patient wait times before entering a room, by allowing the hospital to compare the effects of various options in processing patients without actually going to the expense of implementing the different types of systems. The hospital added a three-room "Fast track facility" staffed with a nurse and a physician extender, which decreased the average length of stay in the emergency department by 5% to 25%, depending on the acuity of the patient's problem.

Mobile computing - Mobile computing refers to the use of portable input-output devices to make it possible and convenient for medical professionals, and especially doctors, to access and input information included in computerized patient record systems. While the technology is progressing in this area, development has been rather slow for a number of reasons.[27] The demands on mobile computers for medicine are particularly stringent, since it is essential that the technology not impede the work flow (for efficiency sake) or the quality of care provided (for efficacy sake). The physical environment in medicine may involve rugged conditions including spilled liquids and biohazards, requiring a sealed computer. The system must also be ergonomically designed to provide the somewhat conflicting requirements of screen readability, minimized weight, maximum battery life and think-speed response time. Furthermore, to be most effective, the mobile computer must be

networked with other parts of the system, and must be able to maintain data integrity through backup procedures in case of battery failure or some other event. One final barrier to the implementation of mobile computing is the unfamiliarity of physicians with computers, as well as their reluctance to use traditional keyboard devices, which are often viewed as the domain of clerical personnel. Meeting these many requirements will be a challenge in developing mobile computing in medicine, however, with the development of sophisticated CIS and CHIN systems, the advantages of mobile computing will almost certainly support the development of better mobile medical computing devices.

Telemedicine - One of the most exciting developments in medicine today is telemedicine. Effective telemedicine techniques are now available because of a number of new technologies, most importantly document imaging. Coupled with electronic document management systems, such as CIS or CHIN applications, information can now be transmitted over time and space to allow consultations from experts in remote locations.[28, 29] Telemedicine can not only assist in telepathology for improved use of specialists in diagnosis, it can also be used in videoconferencing, allowing effective consultation among professionals in remote locations. Such applications demand a fast network, so a consortia of providers sharing the cost of high-speed lines may be the most effective way to implement such systems. Telemedicine holds much promise for meeting the health care needs of under-served populations in sparsely populated regions and developing countries, as well as maritime medicine and military operations.

WorldWideWeb - Health care providers and professionals have also discovered that using the power of the WorldWideWeb is another way to access information from, and communicate with, other medical specialists, as well as to market health care services. Consumers can take advantage of the system in multiple ways to manage health and health care costs. All of the major on-line services - America Online, CompuServe and Prodigy - offer medical references, support groups and access to the Internet with links to health information worldwide.[30]

Conclusion

The health care industry is undergoing tremendous change. Consolidation within the industry brings the need for better coordination within larger organizational structures. Computerized medical technology is evolving rapidly, and cost constraints from government and private sector sources require increased information for control and billing purposes. Therefore, it is mandatory for hospitals and clinics to maintain their competitiveness through the use of modern technology principles, and integrate information technology and systems as critical parts of the hospital management or operations. In a 1994 HIMSS-Hewlett-Packard survey of 1,033 respondents, 43% indicated that the most important skill required for a healthcare chief information officer is business-strategy development.[31] Clearly the strategic implications of information technology will be a driving force in health care management in the decades to come.

Additional evidence of the importance of information technology in healthcare is the dazzling performance of healthcare information systems companies in the stock market, drawing a flood of investor interest, and attracting capital to the tasks of developing and producing innovative information technology for the industry. The healthcare information sector was once dominated by hospital-oriented financial and accounting software, but is now expanding to include the clinical and networking systems previously described.[32] From calendar year 1994 to 1995, the healthcare information systems index was up 178%, compared with a 35% gain in the NASDAQ Composite Index during the same period. Obviously the market perceives the opportunity for growth in the healthcare information systems industry to be promising, as the health care industry struggles to integrate the centuries old traditions of the art of medicine with new scientific and technological tools. Information technology offers the promise to help achieve the goal of providing high quality health care to those who need it at a reasonable cost.

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